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A Review and Expert Opinion on the Neuropsychiatric Assessment of Motor Functional Neurological Disorders

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Abstract

Functional neurological (conversion) disorder (FND) is a prevalent and disabling condition at the intersection of neurology and psychiatry. Advances have been made in elucidating an emerging pathophysiology for motor FND, as well as identifying evidenced-based physiotherapy and psychotherapy treatments. Despite these gains, important elements of the initial neuropsychiatric assessment of functional movement disorders (FND-movt) and functional limb weakness/paresis (FND-par) have yet to be established. This is an important gap from both diagnostic and treatment planning perspectives. In this article, we performed a narrative review to characterize clinically-relevant variables across FND-movt and FND-par cohorts, including time course and symptom evolution, precipitating factors, medical and family histories, psychiatric comorbidities, psychosocial factors, physical examination signs, and adjunctive diagnostic tests. Thereafter, we propose a preliminary set of clinical content that should be assessed during early-phase patient encounters, in addition to identifying physical signs informing diagnosis and potential use of adjunctive tests for challenging cases. Although the clinical history should not be used to make a FND diagnosis, characteristics such as acute onset, precipitating events (e.g., injury, surgery), and a waxing and waning course (including spontaneous remissions) are commonly reported. Active psychiatric symptoms (e.g., depression and anxiety) and ongoing psychosocial stressors also warrant evaluation. Positive physical examination signs (e.g., Hoover's sign, tremor entrainment) are key findings, as one of the DSM-5 diagnostic criteria. The neuropsychiatric assessment proposed here emphasizes diagnosing FND using "rule in" physical signs, while also concurrently considering psychiatric and psychosocial factors in the development of a patient-centered treatment plan.

Introduction

Functional neurological disorder (FND), also known as conversion disorder, greatly interested early leaders in neurology and psychiatry. Although largely neglected for much of the 20th century, FND is among the most common conditions encountered by neurologists and neuropsychiatrists and incurs considerable morbidity{1}. Renewed interest in FND has been promoted through neuroscience advancements aiding the understanding of the brain-mind interface{2}. In parallel, a renewed clinical interest in FND led to a greater emphasis on physical examination signs guiding diagnosis, and to a growing repertoire of evidence-based treatments including physiotherapy and psychotherapy{3-6}. Given that neurologists, psychiatrists and allied clinicians often report feeling ill-equipped assessing and managing FND, there is a need to work towards optimizing the neuropsychiatric assessment of this population for both diagnostic and initial treatment planning purposes. This article focuses on motor FND, which includes functional movement disorders (hyper and hypokinetic), thereafter referred to as FND-movt, and functional limb weakness/paresis thereafter referred to as FND-par{7}; the reader is directed to a separate article on psychogenic nonepileptic (dissociative) seizures (PNES), also sponsored by the American Neuropsychiatric Association (ANPA) Committee on Research (CoR){8}.

The biopsychosocial model identifying predisposing vulnerabilities, acute precipitants and perpetuating factors is a prevailing conceptual formulation for FND{7}(see also Supplementary Reference 1). Although all nuanced aspects of the patient history do not need to be fully elucidated for diagnosis and initial treatment planning, factors with prognostic and treatment implications should be assessed{1, 9}. These include co-morbid pain and fatigue, psychiatric comorbidities, active psychosocial stressors, maladaptive behavioral strategies, and illness beliefs among

other factors. To date, there is no established initial approach to the neuropsychiatric assessment of motor FND.

In this article, we performed a narrative review detailing the clinical history and diagnostic evaluation for FND-movt and FND-par including: time course, precipitating factors, symptom evolution, medical and family histories, psychosocial factors, psychiatric comorbidities, personality characteristics, physical examination signs, and adjunctive diagnostic tests. Thereafter, we provide suggestions regarding the core elements of the neuropsychiatric assessment, integrating neurological and psychiatric aspects, that should be performed in the early phases of clinical care based on expert opinion from the American Neuropsychiatric Association (ANPA) Committee on Research (CoR) and a select panel of international FND leaders. The aim is to help promote a uniform, practical neuropsychiatric interview and physical examination that can be used clinically to both guide diagnosis and the development of a patient-centered treatment plan.

Approach

We aimed to identify published cohort studies written in English in FND-movt and FND-par using PubMed, PsychInfo and the Cochrane Database from inception thru August 2019 using the following search terms: “functional neurological disorder” OR “conversion disorder” OR “functional neurological symptom disorder” OR “functional movement disorder(s)” OR “psychogenic movement disorder(s)” OR “functional gait” OR “psychogenic gait” OR “astasia-abasia” OR “astasia abasia” OR “functional tremor” OR “psychogenic tremor” OR “functional dystonia” OR “psychogenic dystonia” OR “fixed dystonia” OR “psychogenic tic” OR “psychogenic jerk” OR “psychogenic myoclonus” OR “functional limb weakness” OR “psychogenic limb weakness” OR “psychogenic weakness” OR “functional weakness” OR “psychogenic paralysis” OR “functional paralysis” OR “hysterical weakness” OR “hysterical tremor” OR “hysterical gait” OR “hysterical dystonia” OR “hysterical jerk” OR “hysterical tic” OR “hysterical myoclonus”. Exclusion criteria included review articles and studies in isolated PNES, sensory forms of FND, and functional speech and voice disorders. Also, articles investigating the pathophysiology of FND (e.g., functional neuroimaging, autonomic/neuroendocrine studies) were excluded. After reviewing the available evidence, core elements of the neuropsychiatric assessment for FND-movt and FND-par were proposed and agreed upon by all co-authors (see discussion).

Review – State of the Evidence

The following content is organized to provide evidence supporting elements of the clinical interview, physical examination and adjunctive tests that can be considered in the early assessment of patients suspected of FND-movt and/or FND-par.

Clinical Interview

Onset: Demographics

FND-movt and FND-par usually begin in middle adulthood but can affect children (documented as early as age 6){10} and the elderly{11}(see also Supplementary Reference 2)). The common age of presentation is between 39-49{11-14}(see also Supplementary References 3, 4). A bimodal age distribution was reported in one study{11}, with a low average of 35.5 (*n*=118, 89% female) and a high average of 63.5 (*n*=33, 76% male). In some phenotypes, age of onset can help refine the differential diagnosis, such as when Tourette's syndrome (onset typically between ages 3-9) or Parkinson's disease (usually after 50) are suspected{15}(see also Supplementary Reference 5). A female predominance was identified across FND-movt and FND-par including in pediatric populations{16}(see also Supplementary References 6, 7), with a range of 63-89% in studies with *n*≥80{11-14}(see also Supplementary References 3, 4).

Onset: Tempo

The onset is often sudden, including in pediatric populations{17}(see also Supplementary References 7-9). One study found 97% (147/151) FND-movt patients had an "abrupt onset"{11}, while a smaller study found 50% (15/28)(see Supplementary Reference 10). In terms of time-scale, in a FND-movt cohort (*n*=50), 54% reported sudden onset within seconds-minutes, while 36% developed symptoms

over hours to one day{18}. In a FND-par cohort (*n*=107), 46% reported sudden onset while awake, and another 15% first experienced symptoms on waking from sleep or general anesthesia{19}. In a predominantly pediatric cohort, all 70 patients had abrupt or rapidly progressive onset(see Supplementary Reference 2). FND-movt and FND-par (in older patients) are common stroke mimics{11, 12, 20}, with a meta-analysis reporting that FND makes up 13-18% of all stroke mimics{21}.

In FND-movt semiologies, an abrupt onset occurred in functional tremor (67-73%)(see Supplementary References 11, 12), parkinsonism (71%)(see Supplementary Reference 5), dystonia (50%)(see Supplementary Reference 13), and myoclonus (52-61%){22}(see also Supplementary Reference 14). Less frequently encountered subtypes such as functional stereotypies{23}, tics{15} and facial movements{24} also showed high rates of abrupt onset (80-100%).

Onset: Precipitating Factors

Precipitants occur in two broad categories, physical/medical events{25} and emotional stressors (at times intertwined). A few studies noted the scale of proximity, which generally ranged from minutes to within 3 months{18, 26}. For emotionally relevant events{11, 27-30}(see also Supplementary References 3, 10, 15-19), these instances were described using terms such as “emotional/life event,” “adjustment problem,” “severe life event,” “high escape stress,” or simply “stress”{11, 26, 31}(see also Supplementary References 3, 10, 15, 17, 20-22).

Studies on FND-movt reported precipitating factors in 48-80% of cases{11, 18}(see also Supplementary Reference 10, 23). In three studies totaling 229 cases, the prevailing trigger was injury of the affected limb in one-fourth of cases{11, 18}(see

also Supplementary Reference 10). In a FND-movt cohort (*n*=50), triggering events included injury (22%), infections (18%), another neurological condition (16%), and a drug reaction (6%){18}; in this cohort, 70% also reported physical panic symptoms at onset. In 49 patients, 87% reported psychological precipitants such as death of a relative, marital problems, poverty, and unemployment(see Supplementary Reference 23). Studies on FND-movt subtypes generally showed the same trend. In functional tremor (*n*=70), 51% identified a trigger, most commonly physical injury(see Supplementary Reference 12). In functional dystonia, physical triggers such as injury or surgery were common (63-78%)(see also Supplementary Reference 13), consistent with the overlap with complex regional pain syndrome{32}(see also Supplementary Reference 24). Precipitating factors for other functional subtypes such as parkinsonism(see Supplementary Reference 5), myoclonus{27}(see Supplementary Reference 14), tics(see Supplementary Reference 25), paroxysmal FND-movt{28}, hemifacial spasm{31}, and other facial movement abnormalities{24} occurred at rates of 37-88%, with injuries and accidents predominating.

In FND-par (*n*=107), 81% reported a precipitant, commonly panic attacks (34%), dissociative symptoms (25%), pain (21%), and migraine headaches (10%). In this cohort, physical injury was reported in 20% of cases with abrupt onset{19}. In a systematic review, 162 out of 397 individuals with FND-par reported a physical trigger, commonly motor vehicle accidents and limb injury{25}.

In pediatric FND, stressful life events—often cumulative—are commonly reported (47-81%){10, 16, 33}(see also Supplementary Reference 6-8), although reports are less likely in acute care settings{34} and more frequent when evaluated as part of longitudinal care{35}(see also Supplementary Reference 9). Physical stressors

including injury, illness or a medical procedure are common (40-64%){35, 36}(see also Supplementary References 8, 9). Psychological stressors can include family conflict, bullying, separation from a family member, death of a friend or family member, family illness, and school/learning stressors{16, 35, 36}(see also Supplementary References 6, 7).

Illness Course and Clinical Presentation

For adults with FND-movt, average illness duration at diagnosis is reported between 2-10 years in most studies{11, 18, 23, 24, 27, 37, 38}(see also Supplementary Reference 5, 10-14, 22-24, 26). Illness duration at diagnosis for FND-par was variable across studies{14, 19, 39}(see also Supplementary Reference 2).

The illness course is often variable in intensity, and symptoms can evolve or wax and wane considerably. The clinical course of functional tremor can be static, progressive, fluctuating, and/or show spontaneous improvements(see Supplementary Reference 12). Functional dystonia spreads to other body parts in about half of cases(see Supplementary Reference 24), and generalizes in 22-31%(see Supplementary References 13, 24). In paroxysmal FND-movt, 7 of 26 patients had varied presentations across attacks{28}. Symptom self-report can also diverge from objective data. One study found a mismatch between subjective and objective occurrence of functional tremor{38}, though these observations were not replicated in another study{40}.

Although mixed functional symptoms are common in adults (1 in 4 individuals had mixed features of FND-movt, FND-par and/or PNES in one cohort, *n*=100){39}, multiple motor symptoms are particularly common in children (50-75%)(see

Supplementary Reference 7-9), as are comorbid functional sensory symptoms and PNES (36-69%){16, 35}(see also Supplementary Reference 6).

Phenotype-specific characteristics of movement disorders should also be considered{41}. Phenotype-specific characteristics can be especially important in paroxysmal disorders when direct neurological examination of the dysfunction is limited. For example, in contrast to primary ("organic") tic disorders, functional tics are usually not preceded by premonitory urges{15}. Similarly, while children with Tourette's syndrome can often temporarily suppress their tics voluntarily, this is rarely reported in functional tics{15}.

Medical and Family Histories

FND-movt and FND-par can predate or accompany other neurological disorders (e.g., migraine){42, 43}(see also Supplementary Reference 27) and/or coexist with pain disorders, fatigue, sleep disturbances, urinary complaints, cognitive symptoms, headache and the presence of other functional somatic disorders (e.g., fibromyalgia, irritable bowel syndrome){14, 37, 39, 44, 45}. Studies in FND-movt reported 17-25% co-occurrence with another movement disorders{28}(see also Supplementary References 10,12). Crucially, FND does not preclude the diagnosis of a comorbid neurological condition, and vice versa (including FND pre-dating or coexisting with Parkinson's disease{42}). Additionally, increased rates of surgical procedures (e.g., appendectomies, hysterectomies, sterilization) have been described in FND-par compared to neurological controls{45}. In pediatric FND, pain is the most common comorbidity - present in approximately two thirds of cases (56-77%){16}(see also Supplementary Reference 6, 28). Fatigue, dizziness, nausea, and gastrointestinal concerns are also present in approximately a third of cases{17, 35}(see also

Supplementary Reference 7); medical comorbidities may be less common in children (5-12%)(see Supplementary References 6, 7, 28).

In one study, family history of neurological disorders was present in 55% of patients with FND-movt (*n*=29)(see Supplementary Reference 29). Interestingly, FND-movt can occur across family members, although no clear inheritance pattern has been identified. Social (environmental) interactions are also likely important{46}(see also Supplementary Reference 30). Diagnostically, the absence of a family history of Tourette's syndrome or another motor tic disorder may help support a functional tic diagnosis{15}. A family history of psychiatric comorbidities is also common, reported in 36-68% of individuals with motor FND across two retrospective cohorts{39}(see also Supplementary Reference 16). In pediatric FND, a family history of mental health concerns is often reported (26->48%) with maternal depression and anxiety being the most common{16, 35, 36}(see also Supplementary Reference 6)(Kozlowska).

Other Psychosocial Factors

In adults, unemployment rates varied, with reports between 23-84%{13, 39, 47}(see also supplementary References 16, 18, 21). Patients on or seeking medical disability ranged from 24-55%{14, 39, 47}(see also Supplementary Reference 16, 29). College graduation ranged from 41-85%{13, 39}(see also Supplementary Reference 16), and 53-77% reported being married{13, 14, 47}(see also Supplementary Reference 16). Studies, however, have not shown convincing differences in these variables compared to control subjects.

Past Maltreatment and Other Stressors

Psychosocial histories commonly identified childhood maltreatment and other adverse life events{48}. A history of abuse, often during childhood, is identified in some patients with motor FND, and includes sexual, physical, and verbal/emotional subtypes{31, 39, 45, 47}(see also Supplementary References 15, 16, 20); when childhood maltreatment and/or other adverse life events are present, it is important to note that these events may or may not have some etiological relevance. Sexual abuse is reported by many studies, with rates between 3-37%{31, 39, 45}(see also Supplementary References 15, 16, 20); notably, incidence of sexual abuse in women in the general population is approximately 18%(see Supplementary Reference 31). Physical abuse is also identified in a range of 18-37%, though in fewer studies{39, 45}(see also Supplementary Reference 16). Other experiences include neglect(see Supplementary Reference 32) and parental divorce(see Supplementary References 15, 21). Compared to controls, individuals with FND (excluding PNES) in a meta-analysis were found to be 3.5 times more likely to report lifetime stressors{48}. Other psychosocial factors can include worker‘s compensation, disability claims, unemployment benefits, and pending litigation(see Supplementary References 3, 10). In pediatric populations, maltreatment—sexual abuse, physical abuse or neglect—are reported somewhat less frequently (6-36%){49}(see also Supplementary Reference 7). Stressful family dynamics including excessively high parental expectations for scholastic achievement are other themes in the pediatric literature{10}(see also Supplementary Reference 33).

Categorical Psychiatric Comorbidities and Dimensional Characteristics

Several studies used the Structured Clinical Interview for DSM-IV Axis I (SCID-I) to evaluate psychiatric comorbidities in adults with FND-movt and FND-par{14, 47, 50-53}(see also Supplementary Reference 34). Lifetime comorbidities included major

depression (35-42%), generalized anxiety disorder (7-23%), panic disorder (3-36%), post-traumatic stress disorder (PTSD) (0-24%), somatization disorder (22-27%), and dissociative disorders (~26%){14, 47, 50-52}(see also Supplementary Reference 34, 35). In pediatric FND, anxiety (18-100%){10, 16, 54}(see also Supplementary References 6, 36) and mood (9-16%){16, 54}(see also Supplementary Reference 6) disorders were common.

In adults, self-report questionnaires can complement categorical diagnoses. One study showed that group-level differences in the frequency of psychiatric diagnoses were not appreciated in FND-movt vs. focal hand dystonia using SCID-I diagnoses; however, depression and anxiety self-report scores were elevated in FND-movt compared to focal hand dystonia{47}. In FND-movt, depression scores positively correlated with symptom severity{55}. One study showed that 34.5% of individuals with FND-movt reported being alexithymic (inability to put emotions into words), with associations found between alexithymia and obsessive-compulsive personality disorder identified in this cohort{53}.

On dissociation scales, psychological dissociation rates were similar to healthy controls in one study{47}, but another reported a positive correlation between FND severity and dissociation{56}. Elevated dissociation correlated with childhood abuse burden in 60 patients with FND-mixed (55% with FND-par){57}. Studies showed conflicting results regarding whether dissociation tendencies differed across motor FND and psychiatric populations(see Supplementary References 37-40). Hypnotic suggestion rates have been inconsistent(see Supplementary References 41-43).

Increased harm avoidance and impulsivity, decreased novelty seeking, self-directedness and active problem-solving, and an external rather than internal locus of control have all been described in motor FND{58-60}(see also Supplementary References 44-46). By contrast, a recent study in FND-movt showed that patients reported higher general and health-specific internal locus of control compared to neurological controls{61}. In mixed motor FND, fearful attachment positively correlated with alexithymia and depression scores{62}. In pediatric FND, increased questionnaire scores for emotional difficulties, peer problems/social skills difficulties, somatic symptoms, anxiety, depression, stress, internalizing and externalizing, and negativity bias were found{63}. In addition, pediatric FND studies showed high rates of insecure attachment and unresolved trauma/loss{35}.

Illness Perceptions

Illness perceptions have been characterized in FND-par{14, 64, 65}, with patients with FND-par and neurological controls having similar illness perceptions in most domains. Compared to other neurological conditions, however, individuals with FND-par were more likely to believe that their illness was a mystery and less likely to agree that stress was etiological{14}. Furthermore, compared to PNES, individuals with FND-par more strongly rejected psychological mechanisms{64}.

Suicidality and Self-Harm

Some patients with motor FND report prior suicidal ideation or suicide attempts{39, 66}(see also Supplementary References 3, 10, 18), self-injurious behaviors{14}, and psychiatric hospitalizations{39}. Elevated dissociation, alexithymia, depression, and anxiety scores were seen in individuals with mixed FND with prior suicidality compared to mixed FND patients without suicidality{60}.

Personality Disorders and Dimensional Assessments

In one cohort study (*n*=31), one in three FND-movt patients met criteria for a personality disorder{50}; a similar observation was found in a separate cohort{67}. Associations between FND-movt, obsessive-compulsive personality disorder{53} and dependent personality disorder(see Supplementary Reference 47) have been reported. Using a self-report measure, no differences in personality disorders were identified between FND-movt (*n*=51), neurological controls (*n*=34) and healthy subjects (*n*=52){56}. In 20 individuals with FND-par, 50% met SCID-II criteria for a personality disorder, 7% with borderline personality disorder(see Supplementary Reference 21). In a FND-par cohort (*n*=30), 50% had a personality disorder (5 with histrionic personality disorder)(see Supplementary Reference 48). Associations between FND and avoidant personality disorder have also been described(see Supplementary Reference 35).

Multi-scale instruments, such as the Minnesota Multiphasic Personality Inventory (MMPI/MMPI-2), have also been used for personality assessments. When clinical scales 1 (Hypochondriasis) and 3 (Hysteria) are the highest elevations and are above scale 2 (Depression) in the MMPI, the resulting profile is the “Conversion V” pattern. Although well characterized in PNES, the Conversion V profile has only been identified in some FND-movt patients compared to normative data(see Supplementary References 49, 50). More research is needed to determine the utility of the MMPI in the assessment of motor FND.

Dimensionally, the Big Five personality traits include neuroticism, extraversion, openness to experience, conscientiousness, and agreeableness. One study found that

individuals with FND-movt did not differ from healthy controls on personality scores{52}. Elevated neuroticism and lower openness scores were observed in patients with FND-par compared to neurological controls{45}. Another study found lower extraversion and openness scores in patients with functional dystonia compared to controls{68}; extraversion positively correlated with self-reported adaptive stress coping (resilience) in a mixed motor FND cohort{69}. In pediatric FND, elevated neuroticism scores have also been appreciated{63}. Overall, while elevated neuroticism has been identified in some FND cohorts, characterization of the Big Five personality traits remains only a research topic at present time.

In summary, while some patients report adverse life events, many do not. Additionally, the above described developmental history, medical, neurologic and psychiatric comorbidities, and other psychosocial factors can contribute to predisposing, precipitating and perpetuating FND.

Neurological Examination

Rule-In Signs

A major DSM-5 update for FND was the inclusion of a new criteria, where certain examination features can be used as “positive” signs{4, 5}. This transitioned FND from a “rule-out” disorder to a “rule-in” diagnosis.

Signs used to differentiate FND-movt and FND-par from other neurological conditions have been identified since at least the time of Babinski and Charcot. Only some of these widely-used signs have been validated, and problems remain with respect to unblinding and diagnostic suspicion bias{4, 70}. The plethora of available signs contrasts with the limited evidence on inter-rater reliability and available

specificities/sensitivities. 18 controlled studies{14, 23, 31, 70-77}(see also Supplementary References 51-57) reported on 41 bedside clinical tests for motor FND. All studies had small sample sizes (10-50 patients) and only 3 reported interrater reliability{70, 72, 73}. Most signs were investigated in a single study; only the Hoover's sign was validated in 5 studies{14, 70, 74}(see also Supplementary References 54, 55). The specificities of validated signs was very high (64-100%), with 37 out of 41 signs having a specificity over 90%. The sensitivities were variable (9-100%).

General functional motor signs include distractibility during another task (motor or cognitive), variability (contrasts between what may be observed in the waiting room and during examination or history taking) and expressive/suffering-type effortful expression during examination{70} or gait{73}.

Positive signs for functional gait include dragging monoplegic gait, huffing and puffing, falling towards support, excessive slowness, hesitation, non-economic posture, and knee-buckling{70, 73, 78}. Asking a patient with gait disorder to propel a chair while sitting can show improvement in functional gait(see Supplementary Reference 58).

Positive signs for functional tremor include distractibility, entrainment (abnormal movements take on the frequency of volitional movements performed elsewhere) and increase in amplitude with weight load{75}. An additional sign is the observation that movement suppression of one body part (holding an individual's wrist) is followed by immediate re-emergence of movement in another body part (the so-called whack-a-mole sign){79}.

Positive signs for functional jerks include variability and distractibility. The localization can help diagnostically as functional jerks are often axial when other types of myoclonus occur in the limbs. Arrhythmic jerks of the trunk, hips and knees classically recognized as propriospinal myoclonus can also be functional when functional signs are present (distractibility, variability){22} as well as electrophysiological evidence (see below).

Positive signs for functional parkinsonism include a triad of excessive slowness of movement without decrement (loss of amplitude), increased tone due to Gegenhalten and functional tremor (see above){4, 42, 80, 81}(see also Supplementary Reference 59).

Positive signs for dystonia include typical fixed postures and dramatic changes with interventions (such as placebo or low dose botulinum toxin or physiotherapy){4} as well as lack of sensory tricks{82}.

Positive signs for tics include inability to voluntarily suppress the movement, incomplete premonitory urge, and lack of fully stereotyped movements{15}.

Positive signs for functional oro-facial movements compared to tardive dyskinesia include lack of chewing movements or self-biting, lingual movements without mouth movements, and abnormal speech{23}. Positive functional facial dystonia signs include downward lip pulling, orbicularis oculis spasm, jaw deviation, and platysma overactivation{24, 83}.

Positive signs for FND-par are the sternocleidomastoid test, discordance/inconsistency, collapsing/give-way weakness, drift without pronation, finger abductor sign in hand plegia, flexion-extension sign, Hoover's sign, co-contraction, abductor sign, and spinal injury center (SIC) test{70}(see also Supplementary Reference 56).

In pediatrics, many of the same signs have been used to support a motor FND diagnosis including inconsistency/variability, reciprocal contraction palpable during attempts to use an apparently paralyzed muscle, normal tendon reflexes present concurrently with a flaccid paralysis, Hoover's sign, tremor entrainment, and nondermatomal sensory loss{10, 17, 34}(see also Supplementary References 60, 61).

In summary, DSM-5 diagnostic criteria emphasize that physical examination signs are one of the core elements used to "rule in" a FND.

Adjunctive Tests

Electromyography (EMG) and Accelerometry

Surface EMG can aid detection of features of complex functional tremors(see also Supplementary Reference 62). Early "tremorgrams" illustrated changes in amplitude and frequency, along with resolution with distraction(see Supplementary Reference 63). Time-frequency analysis can illustrate entrainment(see Supplementary Reference 64). Other features more easily demonstrated with electrophysiology include differences in loading with paradoxically increased tremor amplitude in patients with functional tremor due to increased coactivation(see Supplementary Reference 65) and pause of tremor during contralateral ballistic movements{84}. As a cautionary note, Milanov et al. followed 29 patients with functional tremor for over 36 months and found

that the decrease in tremor amplitude during distraction was present in less than half at the initial assessment and the coactivation sign was consistently observed initially; however, with prolonged illness duration these features were less obvious and even disappeared(see Supplementary Reference 66).

EMG in functional myoclonus can identify features incompatible with reflex cortical or brainstem myoclonus, including variable and increased latencies in stimulus induced jerks (which were longer than the fastest voluntary reaction times of normal subjects), variable muscle recruitment patterns within each jerk, and significant habituation with repeated stimulation(see Supplementary Reference 67). In another FND-movt subtype, functional fixed dystonia and “organic” dystonia showed partially overlapping features (reaction times, co-contraction) suggesting that these parameters were not diagnostically useful{85}. In addition, in functional jerky movements there were exaggerated and increased auditory startle reflexes, but with a normal EMG pattern{66}. On EMG, the presence of incomplete motor activation with a twitch superimposed on the recording of voluntary torque is potentially suggestive of FND-par(see Supplementary Reference 68). Overall, surface EMG can be a useful adjunctive test for functional tremor and functional myoclonus, with unclear utility in functional dystonia and other motor FND subtypes.

Accelerometry may also record adjunctive diagnostic features. In functional tremor, the accelerometer captured distractibility, inter-limb coherence and dual task interference(see Supplementary Reference 69). As such, the combination of EMG and accelerometry has been advocated to aid diagnosis in functional tremor{84, 86-88}(see also Supplementary References 70, 71).

Electroencephalography (EEG)

EEG may help diagnosing functional myoclonus by demonstrating the *Bereitschaftspotential* prior to the jerk (a feature of voluntary movement)(see Supplementary Reference 72). However, the *Bereitschaftspotential* is not invariably present{89, 90} and event-related desynchronization has also been proposed{90}. Highlighting this, a study of 65 patients suspected of having propriospinal myoclonus, with 34 reclassified as functional myoclonus and 31 clinically diagnosed with propriospinal myoclonus by movement disorders experts, the vast majority (>80%) had neurophysiological evidence for FND-movt, suggesting the potential unreliability of clinical examination for certain diagnoses even in expert hands{22, 91}.

Transcranial Magnetic Stimulation (TMS)

TMS has been studied in FND-par, revealing normal central motor conduction times and motor evoked potentials (MEPs){92, 93}(see also Supplementary References 73-83); during motor imagery, decreased MEPs have also been described in FND-par compared to healthy controls{92}. In addition, patients with FND-par had a low excitability pattern, which was hypothesized to be an electrophysiological correlate of the inability to perform voluntary movements{92}. Reduced MEPs, however, are not specific for FND(see Supplementary Reference 74). TMS has also been used in functional dystonia, with abnormally high plasticity in primary but not functional dystonia(see Supplementary Reference 84). By comparison, cortical excitability was abnormal in both primary and functional dystonia(see Supplementary Reference 85). Currently, TMS in dystonia is only a research tool.

Neuroimaging

Structural magnetic resonance imaging (MRI) is often important to look for neurological comorbidities which commonly co-occur with FND. Single-photon emission computerized tomography DaTscans can aid in distinguishing neurodegenerative Parkinson's disease from other tremor disorders, including functional parkinsonism and functional tremor which lack a dopaminergic deficit{94, 95}(see also Supplementary References 86-88). Other quantitative MRI approaches remain research tools only.

Other Tests

Kinematic analysis with motion sensors and optoelectric systems are in their early phases of being studied for motor FND{96, 97}(see also Supplementary Reference 89). Other adjunctive tests have included the placebo (immediate) response to botulinum toxin injections{98} and examination under general anesthesia in patients with functional dystonia(see Supplementary Reference 90).

In summary, for diagnostically challenging cases, select adjunctive tests, if available, may provide supporting evidence of motor FND.

Discussion

Initial Neuropsychiatric Assessment for Motor FND

With renewed and growing interest in FND, skill in the neuropsychiatric evaluation of this population is paramount. The literature review detailed above illustrates that not enough large-scale controlled studies are available to formulate definitive guidelines on how to conduct a neuropsychiatric evaluation at this stage. We suggest below, however, based on the available evidence good practices that can both inform diagnosis as well as guide the development of a patient-centered treatment plan:

Clinical History

- The onset, time course, and evolution of motor symptoms should be characterized.
    - Acute onset, spontaneous remissions, and variability in symptomatology are common in FND, but diagnostically nonspecific.
- Enquire about other current or past sensorimotor FND symptoms, including PNES, as mixed symptomatology is common in adults and children.
- Ask about the presence of other physical symptoms:
    - Body pain, headaches, cognitive difficulties, fatigue, sleep disturbances, gastrointestinal concerns, and bowel/bladder symptoms are often reported by patients with FND.
- Evaluate for triggers across physical/medical events and emotional stressors.

Other Medical and Psychiatric Histories

- The concurrent presence of a comorbid functional somatic disorder (e.g., fibromyalgia, irritable bowel syndrome) should be evaluated.

- While an exhaustive psychiatric evaluation may not be initially necessary, active psychiatric symptoms (e.g., depression, anxiety, PTSD, alcohol/substance use disorders, personality disorders and maladaptive personality traits, suicidality, self-injurious behaviors) and prior mental health treatments (e.g., psychotherapy, medication trials) should be assessed to aid triage of therapeutic options.
- The characterization of relevant personality traits and cognitive styles (e.g., jumping to conclusions{99}) may require a more longitudinal assessment.
- For screenings, self-report questionnaires (e.g., the Patient Health Questionnaire-9, General Anxiety Disorder-7, Post Traumatic Stress Disorder Checklist-5, or other questionnaires) provide complementary mental health information in adults. In pediatric FND, self-report questionnaires have less utility{63}. For more information regarding self-report questionnaires, particularly for research purposes, see Pick et al 2020{100} and Nicholson et al 2020.

Psychosocial History

- While an all-encompassing psychosocial history is not necessary in the initial assessment, sensitively incorporating focused inquiries into childhood experiences, developmental trajectories, past or present trauma or abuse (assuming sufficient time to ask appropriately), education and work histories (including disability status and benefits), military service, relationship status, social/community supports, and legal issues (including injury-related litigations) into routine practice can help develop a patient-centered treatment plan.
- In pediatric FND, relational and scholastic difficulties (e.g., stress in the family, academic challenges, bullying, etc.) are also important to assess.

Illness Perceptions and Healthcare Experiences

- Illness perceptions regarding diagnosis and treatment are helpful to explore, particularly so that they can be addressed during diagnostic discussions.
- Additionally, some with FND will have had prior negative experiences with healthcare providers, and inquiring about these instances while also validating the patient's symptom complex can help build rapport and engagement.
- Providers should also obtain a sense of how the patient got to where they are now, what they have been previously told, why they have come into clinic at this time, and what are their goals and motivation levels.

Cautionary Notes Regarding Clinical History

- The clinical history should NOT be used alone to make the diagnosis of motor FND.
- Likewise, all FND symptoms are not "stress-induced"; stressors (as outlined above) are not synonymous with "stress". Many patients describe the presence of or increase in symptoms in low stress situations, sometimes seen in the let-down period, where patients are more relaxed.

Physical Examination Signs

- The detection of physical examination "rule in" signs for motor FND are one of the core diagnostic criteria{5}. Most signs have high specificity, but the use of a single positive sign or some that have low inter-rater reliability should be interpreted cautiously.
- The diagnostic evaluation should include a neurologist, neuropsychiatrist and/or another physician with neurological examination expertise.

- FND can co-exist with, or occur in the prodrome of, comorbid medical-neurological conditions. As such, clinicians should not generalize a robust functional sign (e.g., tremor entrainment) and appropriately consider signs indicating another neurological condition when present (e.g. rest tremor and cogwheel rigidity in a patient with FND-movt and co-morbid Parkinson's disease).
- Clinicians should also consider evaluating other concurrently present symptoms (e.g., pain, fatigue, cognitive complaints, dizziness, etc.) as indicated and/or ensure appropriate tests were run by the general practitioners.

Adjunctive Tests

- In diagnostically challenging cases, EMG and accelerometry data, if available, may support the diagnosis of functional tremor.
- EEG-identified *Bereitschaftspotential* may assist in the diagnosis of functional myoclonus.
- DaTscans may help detect Parkinson's disease in diagnostically challenging tremor cases.

Other Comments

- The initial clinical assessment can be performed by one individual with expertise in the neurological examination and neuropsychiatric interview (e.g., neurologist, neuropsychiatrist) or by an interdisciplinary team.
- A review of medical, neurologic and psychiatric records can also be helpful, including prior diagnoses of a functional somatic disorder, as well as consideration of past surgeries and overall healthcare utilization. This chart review can be particularly helpful in 3 ways:

- Some patients with motor FND may have paroxysmal (or fluctuating) physical examination signs, such that noting previously documented “rule in” signs by another physician can be helpful (though important to not solely base one’s diagnostic impressions on the impressions of another).
- This will avoid repeating unnecessary tests if previously performed.
- It will show patients that the diagnosis is carefully made based on positive signs, clinical interview and chart review, aiding the therapeutic relationship.

Future Directions & Conclusion

As we move forward in disseminating the suggested clinical approach, and likely in the future, further refining the motor FND neuropsychiatric assessment based on new research, there is currently a considerable need to educate practicing clinicians, trainees (and supervisors) across the clinical neurosciences in this approach. Considerable challenges exist, including the increasing pressures to evaluate patients as quickly as possible, a healthcare trend increasingly focused on efficiency that does not generally serve well complex patients, including those with FND. Furthermore, neurologists would benefit from added training in neuropsychiatric principles, while psychiatrists working at this interface require increased training in the neurological examination and neurological differential diagnosis. We hope that the neuropsychiatric approach to the assessment of motor FND detailed here will inform diagnosis and management, integrating physical and mental health aspects of patient care in this common and underserved neuropsychiatric disorder.

Table Captions/Titles

Table 1. Clinical History Elements Commonly Found (Yet Non-Specific) in Motor Functional Neurological Disorders.

Table 2. Examples of Positive "Rule-In" Signs of Functional Movement Disorders and Functional Limb Weakness.

Table 3. Adjunctive Diagnostic Tests For Consideration in Diagnostically Challenging Cases.

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Table 1.

Clinical History Elements Commonly Found (Yet Non-Specific) in Motor Functional Neurological Disorders.	
Age at onset	Between 39-49 years old (mean range), with a female predominance. Also occurs in pediatric and geriatric populations.
Tempo of onset	Sudden onset in a majority of cases (>50%).
Precipitating factors	A precipitating factor occurring in close temporal proximity with symptom onset can often be identified (48-80%) such as injuries, accidents, surgeries, other medical procedures, and emotionally-valenced events.
Associated functional neurological symptoms	Mixed functional motor symptoms are common in adults, and especially in children (50-75%).
Other associated physical symptoms	Comorbid pain, fatigue, dizziness, gastrointestinal complaints, sleep difficulties and cognitive complaints are common.
Illness course	The illness course can show waxing and waning patterns, including periods of spontaneous remissions.
Medical comorbidities	In adults, can co-exist with other medical/neurological conditions, including for example another movement disorder (17-25%). Medical co-morbidities less common in children.

Family history	Neurological and/or psychiatric disorders can be found in the family. A maternal history of depression/anxiety is common in pediatric populations.
Psychosocial history	Childhood maltreatment (abuse and neglect) is commonly identified but not universally present. Stressful family dynamics or scholastic challenges are relevant themes in pediatric FND.
Psychiatric comorbidities	In adults, co-morbid psychiatric conditions are frequent: major depression (35-42%), generalized anxiety (7-23%), panic disorder (3-36%), post-traumatic stress disorder (0-24%), somatization disorder (22-27%), and personality disorders (20-30%). In children, mood (9-16%) and anxiety disorders (18-100%) are common.

Table 2.

Examples of Positive "Rule-In" Signs of Functional Movement Disorders and Functional Limb Weakness.
GENERAL SIGNS
Distractibility
Variability (e.g. difference in symptom severity between history taking and exam)
Suggestibility
GAIT
Dragging monoplegic gait
Knee-buckling
Non-economic posture
TREMOR
Variability
Distractibility
Entrainment
Spread of tremor to another body part if the tremor is restrained
JERKS
Predominantly axial
Distractibility
Variability

PARKINSONISM

Excessive slowness without loss of amplitude

Increased tone without cogwheel rigidity

Concurrent functional tremor

DYSTONIA

Fixed posture (typically hand flexion with

sparing of digit I and II, or fixed ankle inversion)

Lack of sensory trick/geste antagonist

TICS

No voluntary suppression

No or atypical/incomplete premonitory urge

Movements not stereotypical

WEAKNESS

Hoover sign / Hip abductor sign

Spinal injury center sign

Asymmetry of head rotation

Arm drift without pronation

Give-way/collapsing/global pattern of weakness

Table 3.

Adjunctive Diagnostic Tests For Consideration in Diagnostically Challenging Cases.	
Surface Electromyography (EMG)	May be useful to detect electrophysiological features consistent with functional tremor and functional myoclonus.
Accelerometry	May be combined with EMG data for characterization of features supportive of functional tremor.
Electroencephalography (EEG)	Can aid the diagnosis of functional myoclonus by demonstrating the *Bereitschaftspotential* prior to a jerk.
SPECT DatScan	Can assist in detecting a basal ganglia dopaminergic deficit found in Parkinson's disease.